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Fuelling the future : A comparative exploration of energy prices in India and the US

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Abstract

India's crude oil consumption is expected to continue to increase, driven by economic growth and rising demand for transportation fuels. This will further boost India's dependence on imported oil. The U.S. petroleum industry has several strengths, including its large resource base, technological expertise, and its access to capital. This paper analyses the association between economic conditions and the price of Crude Oil in a cross-country setting. The study uses a secondary data series of two prominent nations throughout 2013-2023. The analysis revealed a significant long-term price correlation between natural gas and crude oil, indicating a relationship between the prices of these energy commodities. The ramifications of the study's conclusions hold significant relevance for investors and politicians. Investors should be aware that the cost of crude oil will likely be higher during economic uncertainty and inflation. Policymakers should also be mindful of Crude Oil's role in the financial system and take steps to mitigate any potential risks.

Subject Classification: *91B70, 91B84.*

Keywords: *Crude oil, Causality, Co-integration, India, US.*

Introduction

After World War II, natural resources like crude oil and natural gas emerged as essential energy sources, especially for industrial production and transportation (Wen *et. al.*, 2022). These energy products are becoming essential in both developed and developing countries. In the energy commodities market, crude oil holds the most significant stake, making up over 40% of the world›s total energy commodity consumption (Guan *et.*

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al., 2021). The unpredictability of crude oil prices causes concern for economies, especially those that rely on oil. India›s crude oil production has declined recently while consumption has steadily increased. This has led to a growing dependence on imported oil, which accounts for over 80% of India›s consumption of crude oil. India›s crude oil production has declined recently due to a maturing domestic oil field and a lack of discoveries. 2022-23, India produced 29.7 million metric tonnes of crude oil. India›s crude oil consumption has steadily increased due to economic growth and rising demand for transportation fuels. 2022-23, India consumed crude oil worth 254.5 million metric tonnes. The transportation sector is India›s biggest crude oil consumer, followed by the industrial and residential sectors. India›s growing dependence on imported oil is a significant concern for the country›s energy security. The country is vulnerable to fluctuations in global oil prices and supply disruptions. The government is trying to reduce its dependence on imported crude oil by encouraging renewable energy and increasing domestic crude oil production.

The US is the world's leading producer and consumer of crude oil. In 2022, the U.S. manufactured 11.6 million barrels of crude oil daily and consumed 19.78 million barrels daily. This indicates that the United States imported an average of 8.18 million barrels of crude oil daily in 2022. Crude oil production in the U.S. has been growing in recent years due to the development of new technologies such as hydraulic fracturing and horizontal drilling. However, consumption has also been increasing, and the United States remains a net importer of crude oil. The transport sector is the largest customer of petroleum merchandise in the U.S., accounting for about 70% of total consumption. Other significant consumers include the industrial sector (24%) and the residential and commercial sectors (6%). The United States has a large and diverse petroleum industry, with operations in all 50 states. The industry employs over 1 million people and contributes billions of dollars to the U.S. economy.

The literature and objectives are covered in the third section. The research methodology is presented in the third part. Section four delivers empirical analysis. The article is concluded in the fifth section.

Review of Literature

Many researchers have looked at the relationships between commodities such as natural gas, crude oil, and other economic indicators that give a detailed understanding of the correlation between two variables. Consequently, the literature investigation contributes to the compilation of a thorough understanding of how the commodities market operates and other factors that affect the price of energy commodities.

The relationship between the crude oil market and the stock indices of the BRICS countries was examined by Bouslama (2023) using a copula and discovered that the financial markets and crude oil have a fractional co-integration. The lined ARDL model indicated a favorable connection between the crude oil prices and the Nigerian stock market in the long and short term. The short-run correlation was significantly more significant. In particular, the long-term association was affirmative but not statistically significant, whereas the short-term association was significantly positive (Jiang *et. al.,* 2022; Kumar, 2021; Kumar, 2022).

The price unpredictability of natural resources has detrimental macroeconomic repercussions that could eventually stand in the way of sustainable economic development (Liu *et. al.*, 2022; Karakas *et. al.,* 2022). Fuel crises include the Arab oil embargo (1970), the Iran Revolution (1978), the Iran and Iraq conflict of 1980, the Gulf War in 1990, and the present Covid-19 pandemic epidemic of 2020 and 2008 financial crisis increase crude oil price volatility, that has a significant effect on both national and global economic development. Moreover, the financial outcomes of countries that import oil are significantly influenced by the price of natural resources. A natural resource's price rise reduces demand for the resource and consequently slows economic activity; conversely, a resource's price fall encourages economic development (Akinsola & Odhiambo, 2020; Ghahramani *et. al.,* 2022). Because of the profits generated by the world crude oil market, an increase in the price of fossil fuel encourages economic growth in the nations that export oil (Akanni, 2007).

Previously mentioned changes in the cost of goods derived from natural resources can harm economic growth. On the other hand, additional study indicates that financial growth benefits from the natural resource commodity prices' volatility (Atil *et. al.,* 2020)—the current path of fossil fuel research and the contradictory empirical outcomes.

Previous research has shown that several different aspects and criteria influence how much energy goods cost. Many scholars have offered various strategies and solutions to address price variations based on this research. However, a critical point remains unanswered: the relative position of price dependence across different countries.

This research investigates the price dependency of energy commodities in the United States and India within this setting. The null hypothesis is stated as there is no price association between the energy commodities of India and the U.S.

Data and Methodology

Secondary data is acquired from the commodities exchanges in the respective nations. The data comprises natural gas and crude oil, two

significant commodities produced and consumed in two significant countries: India and the United States. These commodities are traded both domestically and globally. The daily return of all Energy Products from the two countries between April 2013 and March 2023 is considered in the analysis. The paper does an empirical analysis in an effort to confirm the correlation between energy commodity prices. The existence of a correlation does not always indicate a causal relationship in either direction. Useful data on whether the price of energy commodities in the U.S. influences the price in India or vice versa can be obtained using causality tests. Using time series data (2013–2023) to determine whether there is a long-term correlation between the price of energy products in India and the U.S. economy, the empirical study will use Johansen co-integration test procedures. The long-run price association between energy commodity prices in India and the U.S. will be investigated using the VECM test. In contrast, the short-term price association will be assessed using the Wald test.

Data Analysis

Table 1 shows that the J.B. test output findings are examined at a 5% significance level to validate the data behavior, revealing that all four data series are typically distributed. In other words, these prices follow a predictable pattern, allowing us to forecast their pricing shortly

Table 1

Test of Normality (JB Test)

	Crudeoil_ India	Crudeoil_ US	Naturalgas_ India	Naturalgas_ US
Mean	-1.86E-05	-0.00031	-3.72E-05	-8.17E-05
Median	0.000197	0.000143	-6.19E-05	0.000201
Maximum value	0.205905	0.078793	0.098022	0.101292
Minimum value	-0.20562	-0.7901	-0.06127	-0.05435
Standard Deviation	0.010876	0.018321	0.011298	0.011362
Skewness	-0.84042	-32.3076	0.380684	0.263162
Kurtosis	121.5457	1390.323	7.922942	8.167139
Jarque-Bera	1458300	2.00E+08	2631.428	2860.616
Probability	0	0	0	0
Sum	-0.04635	-0.76866	-0.0946	-0.20787
Sum Sq. Deviation	0.29442	0.835487	0.324726	0.328446
No. Observations	2490	2490	2545	2545

Table 2

Testing of Stationary through ADF test and PP test

ADF test and PP test(Level & Intercept)									
	ADF		PP			ADF		PP	
T- critical values	t-Statistic	Prob	t-Statistic	Prob	T- critical values	t-Statistic	Prob	t-Statistic	Prob
Crudeoil_India	-19.184	0	-51.632	0.0001	Naturalgas_India	-24.761	0	-36.341	0
1%	-3.4328		-3.4328		1%	-3.4327		-3.4327	
5%	-2.8625		-2.8625		5%	-2.8625		-2.8625	
10%	-2.5673		-2.5673		10%	-2.5673		-2.5673	
Crude Oil_India has unit root.					Naturalgas_India has unit root.				
Crudeoil_USA	-25.416	0	-34.817	0	Naturalgas_USA	-26.595	0	-36.771	0
1%	-3.4328		-3.4328		1%	-3.4327		-3.4327	
5%	-2.8625		-2.8625		5%	-2.8625		-2.8625	
10%	-2.5673		-2.5673		10%	-2.5673		-2.5673	
Crude Oil_USA has unit root.					Naturalgas_USA has unit root.				
ADF test and PP test(Trend & Intercept)									
Crudeoil_India	-19.215	0	-51.639	0	Naturalgas_India	-24.757	0	-36.333	0
1%	-3.9617		-3.9617		1%	-3.9617		-3.9617	

Contd...

5%	-3.4116		-3.4116		5%	-3.4116		-3.4116	
10%	-3.1277		-3.1277		10%	-3.1277		-3.1277	
Crude Oil_India has unit root.					Naturalgas_India has unit root.				
Crudeoil_USA	-25.438	0	-34.823	0	Naturalgas_USA	-26.592	0	-36.762	0
1%	-3.9617		-3.9617		1%	-3.9617		-3.9617	
5%	-3.4116		-3.4116		5%	-3.4116		-3.4116	
10%	-3.1277		-3.1277		10%	-3.1277		-3.1277	
Crude Oil_USA has unit root.					Naturalgas_USA has unit root.				
ADF test and PP test(None)									
Crudeoil_India	-19.187	0	-51.641	0.0001	Naturalgas_India	-24.766	0	-36.331	0
1%	-2.5659		-2.5659		1%	-2.5659		-2.5659	
5%	-1.941		-1.941		5%	-1.9409		-1.9409	
10%	-1.6166		-1.6166		10%	-1.6166		-1.6166	
Crude Oil_India has unit root.					Naturalgas_India has unit root.				
Crudeoil_USA	-25.421	0	-34.825	0	Naturalgas_USA	-26.598	0	-36.779	0
1%	-2.5659		-2.5659		1%	-2.5659		-2.5659	
5%	-1.941		-1.941		5%	-1.9409		-1.9409	
10%	-1.6166		-1.6166		10%	-1.6166		-1.6166	
Crude Oil_USA has unit root.					Naturalgas_USA has unit root.				

The results of a stationary test for each energy commodity and each country are displayed in Table 2. This indicates that the stationary is true in this circumstance, meaning that all data sets of natural gas and crude oil from all countries—India, the US, etc.—are stationary, which indicates that the mean, variance, and covariance are constant. As a result, the study can be quickly accepted and expanded into a generalized statement.

Table 3

Pearson's Correlation

	CRUDEOIL_INDIA	**CRUDEOIL_US**
CRUDEOIL_INDIA	1	0.026097177
CRUDEOIL_US	0.026097177	1
	NATURALGAS_INDIA	NATURALGAS_US
NATURALGAS_INDIA	1	0.030659
NATURALGAS_US	0.030659	1

To obtain the objective of the research, the first examination needed to confirm the strength of the association between the variables—that is, the nations according to energy products—which was determined by a correlation test and is shown in Table 3. Merely 2.6% of the relationships between the variables for Energy Products' Crude Oil and Natural Gas indicate a weak but utmost degree of associations between all the variables—that is, 3.1% of the relationships between India and the USA. Given that both India and the US are significant oil consumers and participants in the global oil market, there is a strong correlation between the two countries' crude oil prices. This implies that variations in the price of oil globally will often have a comparable effect on the price of oil in both nations. The correlation between natural gas prices in the United States and India is frequently observed due to these influencing variables. Nevertheless, price variations might also arise due to varied causes that impact individual countries.

Correlation analysis is utilized to determine the degree of association between variables; nevertheless, it is essential to note that this analytical approach does not explain the causal relationship between variables, specifically regarding the relative influence of one variable on another. In other words, the objective is to detect the primary causal association between the variables. Alternatively, to ascertain the causative association amid the variables, it is imperative to employ the causality test, as depicted

Table 4
Granger Causality Tests

	Observations	F-Statistic value	Probability
CRUDEOIL_US does not Granger Cause the CRUDEOIL_ INDIA	2485	1.79327	0.1666
CRUDEOIL_INDIA does not Granger Cause the CRUDEOIL_US		0.46037	0.6311
NATURALGAS_US does not Granger Cause the NATURALGAS_INDIA	2544	4.65831	**0.0096**
NATURALGAS_INDIA does not Granger Cause the NATURALGAS_US		1.70557	0.1819

in Table 4, to assess the causality. The Granger causality outcome, which seeks to identify the causal relationship, is presented in Table 4. To ascertain the price correlation among nations for an energy commodity, such as Natural Gas, the analysis incorporates the lag 2 component. The results suggest that India trails the United States.

Johansen Co-integration Test

The null hypothesis for the test of each pair of energy commodity prices is that the co-integration relationship between two markets does not exist; the alternative hypothesis is that the co-integration relationship between two markets exists.

Table 5
Test of Johannes Co-integration

Energy Commodities	No of Hypothesized Equation	Maximum-Eigen value	0.05	
		Statistic	Critical Value	Probability.**
Crude Oil	None *	470.3300	14.26460	0.0001
	At most 1 *	400.3224	3.841466	0.0000
Natural Gas	None *	523.9386	14.26460	0.0001
	At most 1 *	441.6518	3.841466	0.0000

Table 5 shows energy products with both the maximum and trace statistics value(p-value <0.05), so the Ho that there is no long-term price association amid futures prices of India and US energy products is rejected. There is a long-term price association between the two energy commodity price series. However, this analysis does not show the characteristics of behavior that lie in the long-run or short-run. Thus, the research will integrate a long-run price association test, i.e., vector error correction model VECM in Table 6.

Table 6

Long-run price using VECM- Models

Long run Price association of crude oil India and US through VECM Models								
	t-Statistic	**Prob.**	**Std. Error**	**Coefficient**	**Mean dependent variable**	**-2.53E-05**	**R-squared value**	**0.434032**
C(1)	-11.755	0	0.01828	-0.21488	S.D. dependent variable	0.01562	Adjusted R-squared value	0.43289
C(2)	-28.523	0	0.021732	-0.61985	Akaike info criterion	-6.04527	S.E. of regression	0.011763
C(3)	-16.5831	0	0.018906	-0.31352	Schwarz criterion	-6.03122	Sum squared resid	0.342888
C(4)	-6.60043	0	0.030449	-0.20098	Hannan-Quinn criter.	-6.04017	Log likelihood	7514.223
C(5)	-4.94619	0	0.027063	-0.13386	Durbin-Watson stat	2.088149	F-statistic	380.0676
C(6)	-0.15111	0.8799	0.000236	-3.57E-05			Prob(F-statistic)	0
Long run Price association of Natural Gas India and US through VECM Models								
	t-Statistic	Prob.	Coefficient	Std. Error	Mean dependent var	-8.34E-07	R-squared	0.296235
C(1)	-19.5528	0	-0.41242	0.021093	S.D. dependent var	0.013434	Adjusted R-squared	0.294848

Contd...

C(2)	-6.22333	0	-0.13336	0.021429	Akaike info criterion	-6.12905	S.E. of regression	0.011281
C(3)	-9.76723	0	-0.18766	0.019214	Schwarz criterion	-6.11527	Sum squared resid	0.322857
C(4)	-13.1501	0	-0.28949	0.022014	Hannan-Quinn criter.	-6.12405	Log likelihood	7799.088
C(5)	-9.99103	0	-0.1944	0.019458	Durbin-Watson stat	2.06217	F-statistic	213.5791
C(6)	0.016181	0.9871	3.62E-06	0.000224			Prob(F-statistic)	0

The VECM model for Crude Oil indicates that the coefficient C(1) has a negative value of -0.214879. Additionally, the associated p-value is 0.0000, deemed statistically significant at a 5% significance level. The outcome indicates a long-term association between Crude Oil in India and the US. In order to validate the accuracy and reliability of the study, it is imperative to consider the statistical significance of the probability (F-statistics) as an indicator of the robustness of the findings.

The VECM model for Natural Gas indicates that the coefficient C(1) has a negative value of -0.41242. Additionally, the corresponding p-value is 0.0000, indicating statistical significance at a 5% significance level. The outcome above indicates a long-term partnership between Natural Gas India and the United States. In order to validate the accuracy and reliability of the analysis, it is essential to ascertain its veracity by examining the significant character of the probability (F-statistics) associated with it.

The examination of the Wald test as shown in Table 7 reveals the observed consequence of the short-term relationship amid the variables, specifically Natural Gas in India and the United States. The analysis indicates that the chi-square test is statistically substantial at a 5% significance level, providing evidence of a short-term price association for the energy product Natural Gas between India and the United States. However, more than the observed similarities between Crude Oil in India and the US in terms of building short-term price relationships are needed to confirm the presence of such an association. This is due to the lack of statistical significance, as indicated by a p-value> 0.05 in the chi-square test. Therefore, to the study objectives, an analysis is conducted to

Table 7

Short-Term price association between energy commodities using Wald test

Short term Price association between Crude Oil India and US						
Normalized Restriction (= 0)	**Value**	**Std. Err.**	**Test Statistic**	**Value**	**Df**	**Probability**
C(1)	-0.02566	0.020195	F-statistic	2.363333	(2, 2479)	0.0943
C(5)	0.045475	0.025524	Chi-square	4.726666	2	0.0941
Short term Price association between Natural Gas India and US						
C(1)	0.323691	0.019708	F-statistic	135.7287	(2, 2537)	0.0000
C(5)	0.019969	0.019575	Chi-square	271.4574	2	0.0000

determine the extent of the association between energy products based on the ensuing outcome. Before drawing conclusions and making generalizations about the study's findings, it is necessary to ensure that all the analyses conducted support the assumption of the most appropriate fitting models.

Conclusion

Establishing the veracity of the price link between natural gas and crude oil as energy commodities in the US and India was the primary goal of this study. The study sought to comprehend the evolving patterns in the market and better practices by doing this. The results of this study can help practitioners, traders, legislators, and other stakeholders by guiding how to create methods that maximize profitability. The results indicate no interdependence between the pricing of the United States and India. A long-term price link exists between the US and Indian benchmark crude oil prices. The two variables do not exhibit any immediate-term association. There are both long- and short-term correlations in the price relationship between the price of natural gas in India and the US. India relies on the United States' natural gas price to determine its pricing structure. Generally, this research on price associations has sufficient value to ascertain optimal pricing in advance and facilitate informed decision-making about import and export activities.

Additionally, it aids in devising suitable trading strategies for both domestic and international markets. The present study is limited in scope, focusing on a limited number of countries and crops.

Consequently, further investigation is necessary to draw generalized conclusions. This can be achieved by considering larger datasets, incorporating macroeconomic variables, and comprehensively understanding practitioners' psychology. These measures will enhance the accuracy of evaluating reality.

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